# Beta Gauge Particulate Monitoring

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**Summary**

This poster session paper discusses the theory of measuring mass emissions of particulates from electric utility stacks and the application of the beta gauge measuring technique to satisfy this developing monitoring requirement.

All particulate monitors with the exception of the beta gauge are susceptible to measurement errors with changes in particle size, shape, color, refractive index, surface charge, and density. All particulate monitors with the exception of the beta gauge are susceptible to measurement errors with changes in stack temperature, velocity, and moisture. Changes in particle properties or stack operating conditions do not affect beta gauge measurements. Using a beta gauge allows an accurate determination of particulate concentration in all stacks and under all conditions including the most demanding and difficult in the power industry. The beta gauge particulate monitor was developed to:

Measure accurately in wet stacks.

Measure accurately regardless of the fuel being burned.

Measure accurately regardless of the type of air pollution control equipment and techniques used including fabric filters, electrostatic precipitators, dry scrubbers, wet scrubbers, carbon injection, and selective and non-selective catalytic reduction.

Measure accurately regardless of how the fly ash is conditioned including sulfur trioxide injection for low sulfur western coals.

Measure accurately regardless of how the boiler is operated.

Measure accurately regardless of how air pollution control equipment is operated and maintained.

Measure accurately as mill performance degrades over time.

Provide a reliable and accurate control system input to optimize air pollution control equipment at all operating loads.

A beta gauge consists of a sample extraction device, sample transport tubing, filter tape, beta source of Carbon-14, beta detector, chiller, and flow meters. The beta gauge extracts a sample isokinetically from the stack using a dilution probe to suppress moisture and increase sample flow. The sample is transported through a heated line at high velocity to maintain particulate entrainment and prevent sample loss. The sample is drawn through a filter tape which captures all particles larger than 0.1 microns. The beta gauge then moves this filter tape between a low energy Carbon-14 source and a detector to measure the amount of mass captured on the filter tape.

The particulate measurement cycle begins by measuring a clean area (spot) on the tape for a fixed time period to determine a baseline electron count. This clean spot is then moved under a collection apparatus for sample extraction from the stack as detailed above. Once a sufficient amount of sample has been drawn through the filter tape to provide a measurable amount of particulate on the tape, the tape is moved back under the beta source and remeasured for exactly the same amount of time as the initial baseline measurement. The additional mass added to the tape will cause a reduction in the electron count. The ratio of beta transmissions measured from the original clean spot to the collected sample spot is proportional to the mass on the tape.

During the time particulate mass is building up on the tape, the beta gauge is measuring the sample volume extracted from the stack which produced that mass. This volume is measured first on a wet basis and then on a dry basis. The sample is conditioned with a high capacity chiller to remove all moisture to produce the dry basis measurement. Dividing the mass collected by the wet sample and dry sample volumes extracted from the stack provides outputs for mass concentration on both a wet and dry basis.

Reliability and on line sampling time can be significantly increased by using two beta sources and two detectors in the same instrument. This allows one sample to be measured and analyzed while a second sample is being collected. Dual head beta gauges also allow single head measuring should one of the detectors or sources be damaged or become inoperable.

Performance Specification PS-11 for particulate monitors is in the final stages of review before promulgation. This performance specification requires beta gauges to perform daily drift checks on both the beta sources and the flow monitors. This will ensure owners and regulatory agencies that the beta gauge is operating reliably and within specification over extended periods of time. Quarterly mass and flow audits very similar to quarterly opacity monitor audits are also required which will provide additional assurance of a beta gauge's performance and accuracy.

Continuous particulate monitoring is becoming an issue in the electric utility industry for a variety of reasons. The industry has recognized that changes in mill/pulverizer performance, switching or blending fuels, and varying air pollution control equipment operating parameters noticeably affect particulate emission levels. These levels can vary significantly from the values measured during compliance tests which provokes Title V, credible evidence, and compliance assurance monitoring questions. Continuous verification of particulate emission levels will be required for some industrial groups in the not too distant future. Utility environmental managers who must deal with this problem now have a beta gauge option to accurately and reliably monitor particulate emissions under all conditions. The beta gauge will not only guarantee compliance by a direct measurement of mass emissions, but will also provide the signals necessary to optimize the particulate removal process.